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Chemical Warfare: Drugs in Sports

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A number of substances have been used by athletes in an attempt to improve performance in sports. The use of these substances, which are referred to as ergogenic aids, has become widespread; some pose serious health hazards. Ergogenic aids are divided into five broad classifications: physiological, physical, psychological, nutritional and chemical. It is possible, although conclusive proof is lacking, that some substances may give an athlete who takes them an advantage over one who does not. However, the health hazards posed in general by these materials far outweigh any possible advantage.

WITH THE EMPHASIS on winning in sports so predominant today at almost every level of competition—high school, intercollegiate, international and professional—it is easily understandable why an athlete might experiment with substances or methods, other than those of good basic training and coaching, in an attempt to improve athletic performance above the normal physiological level. The motivation for using such methods or substances, referred to as ergogenic aids, may come from fellow athletes, a coach, an athletic therapist or even a physician treating the competitor. An athlete may be influenced by commercial advertising or by exposure to the numerous scientific and pseudoscientific articles appearing in the literature concerning these materials. Generally speaking, however, there are very few substances or materials that will in fact improve normal physiological performance without significant health hazards associated with their use.

Materials Used

Ergogenic aids may be divided into five broad classifications: physiological, physical, psychological, nutritional and chemical. Using these broad headings we may then discuss the more common aids used by athletes in trying to improve their competitive performance.

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Physiological Aids

Oxygen has been used for a number of years in an attempt to improve the supply available to the muscular system during heavy athletic activities. Indeed, the very ability of the body to transport and use oxygen may be the critical factor limiting maximum endurance capabilities. The oxygen may be taken before, during or after an event. A number of studies on the subject have been carried out and the conclusions reached are that oxygen given before a sports event may offer an advantage if taken within two minutes of performance and in short-term events of less than 30 seconds duration. Oxygen taken during an event will increase the partial pressure of oxygen in the blood significantly but its use obviously would be impractical (an athlete would have to carry an oxygen supply during the event). The use of oxygen following an all-out sports effort would be of no use unless the athlete had to return quickly to the same activity.[1]

High altitude training before a contest has been tried on numerous occasions. The rationale is that

the relative polycythemia resulting from training at high altitudes increases the oxygen available to fatigued muscles, thereby improving muscular performance at lower elevations. There are no hard data to support this concept, although training sites are still located at high altitudes in many countries.

Blood doping (boosting) consists of the removal of approximately 1 pint of blood from a competitor three or four weeks before an endurance event. This blood is then stored under the usual sterile, refrigerated conditions. The athlete continues his or her training schedule, and in the intervening weeks before competition the normal blood volume is reconstituted physiologically. The day before the event, the athlete's own blood is reinfused into his or her own vascular tree. The added boost of red blood cells (some of which are still viable) to the reconstituted blood volume thereby gives the recipient a relative polycythemia with an increased oxygen-carrying capacity of that athlete's circulating blood volume. This would then, it is contended, act as an ergogenic aid. There have been a number of conflicting reports in the literature about this alleged positive effect of the added blood.[2-5] The possible dangers of such a procedure include mismatched transfusions, infections and clotting problems, and these alone should mitigate against such practices. Possible dangers far outweigh any possible gain from blood boosting.

Warm-ups should be a part of athletic training. They can have no adverse effects and, at least theoretically, they have a host of advantages, the most significant effect of which may well be psychological. It has been suggested that muscles become more lax during a warm-up and that the resulting elevation of temperatures within the muscles with activity increases the efficiency of the enzyme systems and allows higher metabolic activity of the muscle cells. In addition, hemaglobin releases oxygen more freely at higher temperatures.[6] Finally, there is ample evidence, albeit anecdotal, from athletes that stretching muscles before competition lessens the chance of muscle strains during competition.

Mention should be made of the use of water in athletics. Until just a few years ago it was customary for coaches to prohibit athletes from taking fluids just before or during competition because it was felt that it would impair performance. This custom in itself probably was a contributing factor to many cases of heat exhaustion and heat stroke. It is now recognized that there is no basis whatsoever for restricting water intake by athletes at any time. In addition, there is no evidence to suggest that any other substance is superior to water during competition or training. Salt and mineral loss during strenuous activity is generally not excessive and salt tablets should not be used. An athlete is much wiser to add salt to the regular diet rather than take salt before or during competition. So-called isotonic solutions are acceptable but generally not necessary to athletes who have well-balanced diets and adequate intakes of fluid. The practice of pre-event dehydration by boxers, wrestlers and weight lifters in order to "make weight" must be strongly condemned.[7] Serious health complications from such practices can result.[8]

Physical Aids

In the broad category of physical aids are those mechanical devices designed to increase athletic performance. Examples are aerodynamically designed javelins or fiberglass poles for pole-vaulters. Discussion of this type of aid is not within the scope of this article.

An interesting, even bizarre, new physical aid was reported to have been introduced at the 1976 Olympics in Montreal.[9] A European team, it has been alleged, instilled air into the rectums of their swimmers in an attempt to improve the buoyancy of these athletes. This method, aside from being no doubt very uncomfortable for the athletes, did not seem to noticeably improve the swimmers' performance. If nothing else, however, the incident does illustrate the ends to which coaches, trainers and physicians sometimes go in attempting to aid teams to win medals.

Psychological Aids

There is no doubt that the slim margin that sometimes exists between winning and losing athletes may be a psychological factor. The desire and determination to win are paramount in performance, assuming that an athlete has first achieved peak conditioning through good coaching and training methods. A coach's pep talk is a very simple example; the late Vince Lombardi, for instance, was a master at exhorting and driving his athletes to victory by this means. While psychologists once were disdained as *shrinks* by athletes, coaches, team physicians and, indeed, team managements, athletic psychologists have finally and rightfully been recognized as very im-

portant members of the sports health team. It is interesting that teams from several Eastern bloc countries, who seem to be far ahead of the Western nations in this area of sports medicine, routinely travel to international competitions accompanied by a large team of psychologists.

Nutritional Aids

In no area in sports does quackery and faddism exert a more profound effect than in the nutrition of athletes. In fact, in no other aspect of sports is ignorance more prevalent. Most athletes by nature are highly competitive and consequently susceptible to claims for aids that might supply a competitive edge. Queen bee honey, rose hips tea, various herbal preparations such as ginseng, and of course the omnipresent vitamins (particularly vitamin E), to mention but a few, are purchased in massive amounts by the athletic population. While there is no doubt that vitamin deficiencies will decrease performance, there is no evidence that supplemental vitamins taken in the absence of a deficiency will improve performance. In addition, the general athletic population does not usually suffer from vitamin deficiencies. There are indeed very few items for sale on supermarket shelves that do not contain more than adequate amounts of vitamins occurring either naturally or as additives.

Many misleading and false claims are made by some manufacturers of these coenzymes, and the vitamin industry does a multimillion dollar business annually, the majority of their products doing little else than giving our society an extremely nutritious sewage. Conversely, excesses of certain vitamins may indeed be dangerous to health. Vitamins are not, of course, used up in athletic performance and there are no scientific data showing that excesses of them increase performance in any way. Vitamin E is perhaps the best example; its advocates continue to make extravagant claims of increased performance both in the athletic and sexual fields. It is essentially a vitamin looking for a deficiency disease.[10] The vitamin hoax is a crutch upon which many athletes readily lean, especially when their performance is below that level which they hope to attain.

What has been termed "Vitamin B_{15}" by some is not a vitamin at all but a chemical substance (pangamic acid), and the name has been copyrighted.[11] Its action is unknown, it is not a vitamin, and the Food and Drug Administration has stated that "it is therefore illegal for the substance to be sold as a dietary supplement."[12] Apparently, however, its manufacturers are doing a land-office business in the sale of this product to various professional athletic teams in the United States.[13]

Traditional ideas about the composition and importance of a pregame meal have changed. While at one time many football players would insist on a large steak three hours before competition, the medical profession has finally convinced coaches that steak will in fact still be in the stomach following the game. If the steak is to be eaten it should be following the game. An athlete should eat a light, balanced, easily digestible carbohydrate meal three hours before the event—for instance, pancakes, waffles or spaghetti. Liquid protein nutrient preparations taken before an event are of no immediate value to an athlete. Fluids with high sugar content should not be taken just before competition. Such preparations are of no use during competition, delay emptying of the stomach, and will lead to hypoglycemia due to the demands of the sudden large insulin release and the demands of the contracting muscles during the event on the glycogen supplies. Conversely, starvation for a few days before an event in an attempt to "make weight" should be discouraged. Not only is this practice harmful to health because of the accompanying loss of protein, glycogen, minerals and enzymes, but the performance of the athlete will be decreased.[14]

The carbohydrate loading diet has become an approved dietary manipulation which has shown evidence of improving athletic performance in endurance events. An athlete trains and eats normally until seven days before an event, at which time the training diet is modified for the next three days so that it is composed almost exclusively of protein and fat. The athlete continues to train but on a reduced scale and the muscles are gradually exhausted of glycogen stores in this manner. For the final three days before the competition only carbohydrates are eaten and the theory is that the muscles overreact by storing larger than normal amounts of glycogen. Training is further reduced during these three days with no training being carried out the day before and the day of competition.[15]

Chemical Substances

Under this heading are included all of the chemical substances used as ergogenic aids, largely those pharmaceutical products that are

used (and abused) by athletes. These are the substances that pose the most severe health hazards and at the same time are those most prevalently used in sports. Generally speaking, these materials are specifically prohibited at the international amateur (and in some cases, professional) level. Their use has been widespread in the past and has contributed directly to many deaths.[16] Indeed, members of the lay press, some of whom seem to believe that all athletes in international competition resort to drugs, have on occasion labeled the Olympics as "chemical warfare." A number of sports reporters have written to the effect that medals in competitive sports should be given to the drug houses. It was the suspected widespread use of these products, with their serious hazards to health and related reported deaths, that led the International Olympic Committee (IOC) to legislate against their use at the international amateur level. This led to the institution of urine testing for competing athletes at all levels of international amateur sports, which was carried out in the winter and summer Olympic Games in 1968. An up-to-date list of those substances labeled as forbidden was published just before the Lake Placid Games[17] and is shown in Table 1. Each competing nation was supplied with this booklet before the competition.

Psychomotor Stimulant Drugs

The use of psychomotor stimulant drugs (listed under section A in Table 1) may constitute the major drug-related problem in athletics. There is no doubt that they have been widely used in the past but it is hoped that most athletes now realize their dangers and that usage is declining. There is ample evidence (for example, in many of the autobiographies of former athletes) that these drugs have been abused in sports particularly by professional athletes. A common statement is that "the bennies were right next to the salt tablets in the training room." Apart from the health hazards associated with these drugs, which will be discussed, there are important legal aspects. Several law suits in the recent past have been brought by athletes against team physicians and managers for supplying these drugs to them ad lib. It has been claimed by the athletes that they became dependent on the drugs as a result of this easy availability. At least one physician recently has had his license to practice temporarily suspended because he administered drugs of this nature to athletes. In addition, occasional reports can be found in the news media about professional athletes who have been caught trafficking in these materials.

The use of psychomotor stimulant drugs may in one sense improve athletic performance because the drugs can make an athlete more alert initially and shorten reaction time. However, they also obscure an athlete's physiological fatigue level. That is to say, they allow an athlete to "run the red light" because they mask the normal symptoms of fatigue. This in itself of course can be very dangerous, and obviously could easily prove counterproductive for an athlete in the long term. In addition, use of the drugs can easily mask a

TABLE 1.—*List of Doping Substances*

A. Psychomotor stimulant drugs
e.g.
amphetamine
benzphetamine
chlorphentermine
cocaine
diethylpropion
dimethylamphetamine
ethylamphetamine
fencamfamine
meclofenoxate
methylamphetamine
methylphenidate
norpseudoephedrine
pemoline
phendimetrazine
phenmetrazine
phentermine
pipradol
prolintane
and related compounds

B. Sympathomimetic amines
e.g.
chlorprenaline
ephedrine
etafedrine
isoetharine
isoprenaline
methoxyphenamine
methylephedrine
and related compounds

C. Miscellaneous central nervous system stimulants
e.g.
amiphenazole
bemigride
doxapram
ethamivan
leptazol
nikethamide
picrotoxine
strychnine
and related compounds

D. Narcotic analgesics
e.g.
anileridine
codeine
dextromoramide
dihydrocodeine
dipipanone
ethylmorphine
heroin
hydrocodone
hydromorphone
levorphanol
methadone
morphine
oxocodone
oxomorphone
pentazocine
pethidine
phenazocine
piminodine
thebacon
trimeperidine
and related compounds

E. Anabolic steroids
e.g.
methandienone
stanozolol
oxymetholone
nandrolone decanoate
nandrolone phenylpropionate
and related compounds

Source: Extracted from IOC Medical Controls, XIII Winter Games, Lake Placid, NY, 1980.

serious injury by making it appear less severe. Such drugs can also make an athlete more hostile and aggressive—which may account for much of the unnecessary brutality and rough play seen in professional hockey, American football and some other sports.

A large number of studies carried out with these drugs have been reported in the literature, starting in the 1950's. In one of the classic reports by Karpovitch[18] the investigator concluded that there was no real beneficial effect derived from taking these stimulants. Another report in the same year by Smith and Beecher[19] suggested that perhaps there was an advantage to taking these materials. (This latter study has come under a great deal of scientific scrutiny and criticism.) A recent report in the literature (1980) is by Chandler and coworkers,[20] who indicated that there was probably no substantial improvement of performance with the use of such stimulants.

One of the most powerful central nervous system stimulants, caffeine, has become very popular with athletes. In a study carried out at the 1976 Olympic Games in Montreal, Laurin and Letourneau reported finding significant amounts of caffeine in a large number of the 2,080 urine specimens tested from competing athletes.[21] This material is not banned under IOC rules because it appears so commonly in normal diets in such products as tea, coffee and cola drinks. A recent study on caffeine has also indicated that there is an increased work output with increased ingestion of caffeine due to increased mobilization of fat, an increase in plasma free fatty acids and an increased rate of lipid metabolism.[22]

In regard to another stimulant, cocaine, the author knows of no scientific studies carried out to assess this drug's effects on athletic training or competition.

Sympathomimetic Amines

The sympathomimetic amines (section B, Table 1) are the drugs that cause the most problems to physicians associated with international athletic competitions where testing for drugs is carried out. These are the substances found in common cold remedies, as well as in nasal and optical decongestants. These in fact are the materials that so often turn out to be the cause of positive results of drug tests and lead to disqualification of athletes and in some cases loss of medals.[23] All physicians should be aware that these materials are among those tested for by the IOC. Indeed, a gold medal was lost by an American swimmer in the 1972 Olympics because of a positive test finding for such a drug. It is to be remembered that the urine tests carried out by the IOC are qualitative only and not quantitative; they do not distinguish between therapeutic and so called doping doses. The mere presence of a minute amount of the material is enough to disqualify an athlete. Before the Montreal Olympics in 1976 a double-blind study was carried out on one of the constantly used antiasthmatic compounds containing ephedrine.[24] This study showed no significant improvement of performance in those athletes studied. It is interesting that in the original articles on the subject in the 1950's and 1960's it was suggested that such materials did improve athletic performance. However, in the more recent studies of the 1970's (which would seem to be of greater scientific validity), no significant or appreciable improvement in performance has been shown to occur with the use of these materials.

Miscellaneous Central Nervous System Stimulants

A number of miscellaneous central nervous system stimulants are given in the IOC listing. One example is strychnine which, surprisingly enough, has been used as a stimulant by athletes, particularly cyclists. An American cyclist was reported to have been found using this material in the 1904 Olympics in St. Louis,[16] and the author has recently seen European vitamin preparations containing strychnine used by six-day cyclists.

Narcotic Analgesics

The narcotic analgesics are of course prohibited by the IOC, and their use is clearly dangerous. A number of deaths have been reported from the use of these materials by athletes.[16] Apart from their serious hazards and addictive qualities, they are dangerous because they may allow an athlete to compete with a serious injury by masking the symptoms.

Marijuana is not on the IOC doping list; however, studies have been carried out on its effect on performance in athletics. One fairly recent study by Steadward and Singh reported no significant difference in handgrip strengths, vital capacity and expiratory flow rate in subjects after smoking a placebo or marijuana.[25]

Anabolic Steroids

Anabolic steroids, unfortunately, are widely used in weight lifting and throwing sports. Their

use is extremely common at high school, university, professional and international athletic levels. Regrettably, the lay literature has reported these substances as being responsible for substantially increasing muscle size and consequently strength. The substances do stimulate the synthesis of cellular protein and have an interesting history. They are reported to have been used in World War II by German troops to improve their aggressiveness and strength in battle. Following World War II they apparently were used to help restore the wasted bodies of concentration camp victims and prisoners of war. The medical profession did use them briefly in treatment of osteopenia but use was later abandoned in that area. Steroids have been used extensively in the animal sciences field to increase muscle mass, with its obvious economic advantages in cattle.[26] It has been found, however, that diethylstilbesterol is much more effective in livestock than the anabolic steroids. It is to be noted also that these materials are not used in cattle destined for breeding purposes but rather those destined for slaughter. (The use of these materials in cattle has declined because of recent legislation prohibiting further production of the hormones previously manufactured for this purpose.)

Anabolic steroids still find a useful role in certain medical conditions such as metastatic cancer, aplastic anemia and chronic renal failure. Shahidi has recently reported that these materials given with parenteral iron will significantly increase hemoglobin levels in patients with chronic renal failure.[27]

Many athletes have eagerly seized upon the use of these products, assuming that these materials by increasing muscle size will raise their performance above that level achievable through normal physiological conditions and training. Vast doses of these materials apparently are taken ad lib.

Most of the studies that purport to show beneficial effects of anabolic steroids in athletics should be subjected to very careful scrutiny. For example, some of these studies have not used true double-blind methods. Moreover, the amounts of the materials used in the studies usually are not comparable with the amounts actually used by athletes. Anabolic steroids are, in fact, extremely dangerous; their use by athletes has been condemned by the American College of Sports Medicine.[28] The health hazards associated with the taking of these materials are frightening. One of the effects is salt and water retention which leads to hypertension. A host of other complications have been reported, including hepatitis, jaundice and cancer of the liver. In men, loss of sexual drive, impotency and even testicular atrophy have occurred. In women, hirsutism and deepening of the voice are possible side effects. The use of these compounds by immature humans may result in early skeletal maturation.

These materials do apparently increase appetite and dietary intake. There is an associated increase in training and conditioning at the time these materials are taken and there is no doubt that an increase in muscle size *(bulking)* does occur. Some investigators feel it is these factors that lead to increased muscle size rather than any direct anabolic effect. One of the most recent comprehensive articles published on this subject reported as follows: "We believe, however, that the existence of an anabolic action, which must be the principal basis for consumption by athletes, should be regarded as an open question."[29] On the other hand, a number of published studies have tended to support the thesis that these compounds do improve muscular performance. Moreover, anabolic steroids are highly acclaimed in the athletic world, and this in itself can produce a definite beneficial, psychological effect on athletes taking them. All in all, however, the serious health hazards associated with their use far outweigh any potential gain that might be expected.

Other Chemical Substances

There are other materials taken by athletes in an attempt to improve performance. Beta-adrenergic blockers are an example. These materials have been used by musicians, ballet dancers, public speakers and other persons in whom anxiety and tension may mitigate against a good performance. While these substances may be of some help in reducing anxiety associated with stress, there is no real evidence that their use will increase athletic performance.[30] Diuretics, another example, have been used for a number of years in combination with water and food restriction in sports where weight is a factor. This approach,[7,8] mentioned earlier, should be condemned by physicians, coaches and trainers.

Alkalinizers have been reported as being a possible ergogenic aid.[6] The technique involves ingestion of an alkaline salt following meals for a

few days before and following a competition. Because lactic acid is formed as a result of intensive exercise, it is thought that the use of these substances would result in a higher pH to start with so that the athlete would be able to make more lactic acid before exhaustion and presumably be capable of a greater work output. It has been reported in the doping manual of the IOC that the use of alkalinizers can, by raising the urine pH, lead to a much slower excretion rate in the urine of the by-products of the stimulants occasionally used by athletes. Alkalinizers have also been used in the past in a vain attempt to mask the use of stimulants on this basis.[16]

Alcohol has long been used by competitors in athletic events, in modern times particularly by cyclists, rifle sharpshooters, and participants in biathalons. It is used because of its possible tranquilizing effect, it is a readily available source of carbohydrate and it acts as a diuretic in small amounts. However, alcohol does delay reaction time, and probably most often detracts from performance. It is occasionally tested for at the international level. It can have serious health hazards by masking the normal warning symptoms of fatigue and disinhibiting athletes.

Conclusion

There is no question that the use of ergogenic aids has become widespread among athletes. The increased social, political and economical rewards associated with success in sports increasingly force athletes to improve their performance. An athlete may be persuaded by a friend, fellow athlete, coach, manager, trainer or physician, or even an overenthusiastic parent, to resort to the use of unethical and dangerous practices in an attempt to win. It is apparent, however, that any possible athletic advantage to be gained from the use of any of the various chemical products is far outweighed by the serious health hazards associated with their use. Physicians involved in sports medicine must be aware of the facts related to the use of ergogenic aids and should make an active effort to educate athletes. A physician who makes potentially dangerous chemical substances available to an athlete or a team should be penalized.

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